ECE 445

Revised Design Document

Surgical LED Lamp

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Introduction

1. Problem

Surgeons and medical professionals employ various methods to detect cancerous cells, mostly using their sense of vision and analysis of tissues to determine which cells are malignant and work towards appropriately removing those. However, there is a limit to the human vision especially when dealing with an entity like the human body which is so complex; it is very difficult to detect cancer cells in areas where there is not as much growth and visibility. While biopsies are taken to spot and remove cancerous cells, identifying the exact location of the masses is difficult to locate without a device aiding the surgeon in the location of the masses.

Biopsies and surgeries allow medical professionals to detect cancerous cells; however, it would be far more beneficial if surgeons were able to use a surgical camera nad light to detect cancer in undetected areas. Considering how life threatening cancerous growths are and the fact that cancer is the second most leading cause of death in humans, detection and removal of cancerous cells is of utmost importance. Therefore, there is a critical and growing need to develop tools and methods to aid surgeons in their job of identifying and eliminating cancer cells.

2. Solution

Our solution to this is two-pronged: a microscopic camera and a surgical light. Our team will be working on the surgical light. This lamp will work in tandem with the microscopic camera to better aid cancer specialists to identify cancerous growths during both surgery and early examination. The surgical light solution is a programmable light source that will mainly be used in surgical settings. The light will allow medical professionals to use the infrared light to conduct a thorough examination of different areas that could be affected by cancerous cells. Using different LEDs, such as infrared and visible LEDs, the user can modify the brightness of the light as they deem appropriate and effectively be able to identify cancerous cells that may be harder to see otherwise. Not only will it aid in identifying the location, but it will allow for a more precise identification of where the cancerous cells might be growing. The microcontroller will allow for the adjusting of the brightness and this will be through a connection with a wire. Additionally, an additional LED PCB will be used in order to allow for heat dissipation and terminal release.

The light sources will contain different sets of LEDs. The first set of LEDs would be visible spectrum white LEDs (~400-700 nm) which will be a minimum of 5 kilolux. The second set of LEDs would emit around 700-800 nm infrared light which will be a minimum of 1 milliwatt per cm squared. As a part of the solution, there will be a two layer heat dissipating PCB for LEDs that will defer from a regular PCB that will be designed as the PCB specifically for

LEDs will allow the PCB to not melt.

3. Visual Aid

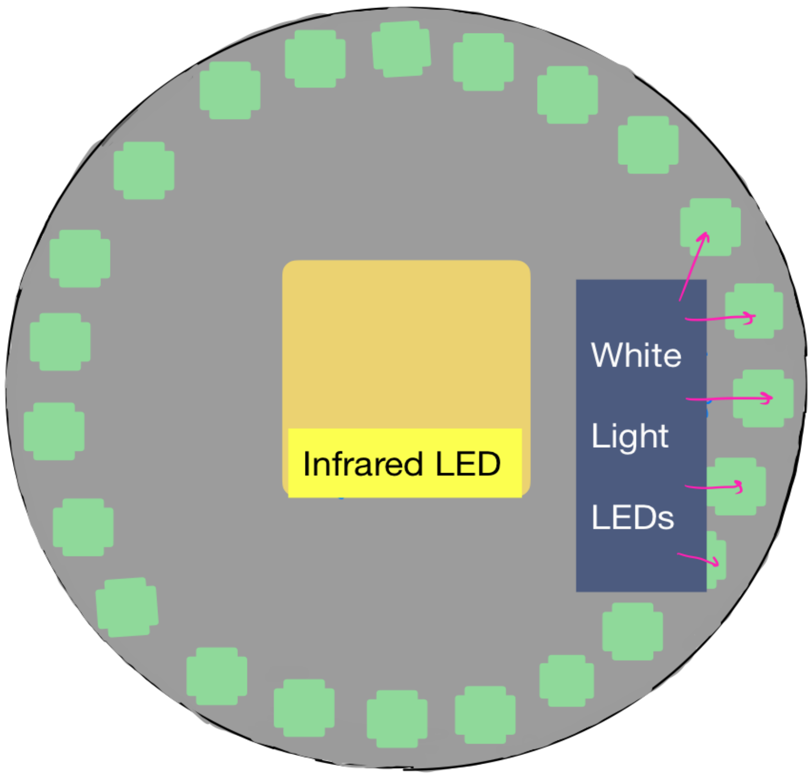


Figure 1. Simpler rendering of our LED PCB board

Our surgical LED lamp would consist of two PCB boards. The first board would house the supporting ICs and other electrical components like resistors, inductors, capacitors etc. The second board which would be 6” diameter Metal Core board which would specifically be for hosting the LEDs and dissipating the heat emitted from them faster.

4. High-Level Requirements

- Employ LEDs and have a way to turn on a set of white LEDs and allow user to aid in detecting cancerous cells
- Employ one infrared LED and develop a way to allow user to turn on infrared LED
- Develop a mechanism to allow user to increase or decrease the brightness of each of the LEDs so they can adjust the brightness of each LED individually

Design

1. Block Diagram and Physical Design

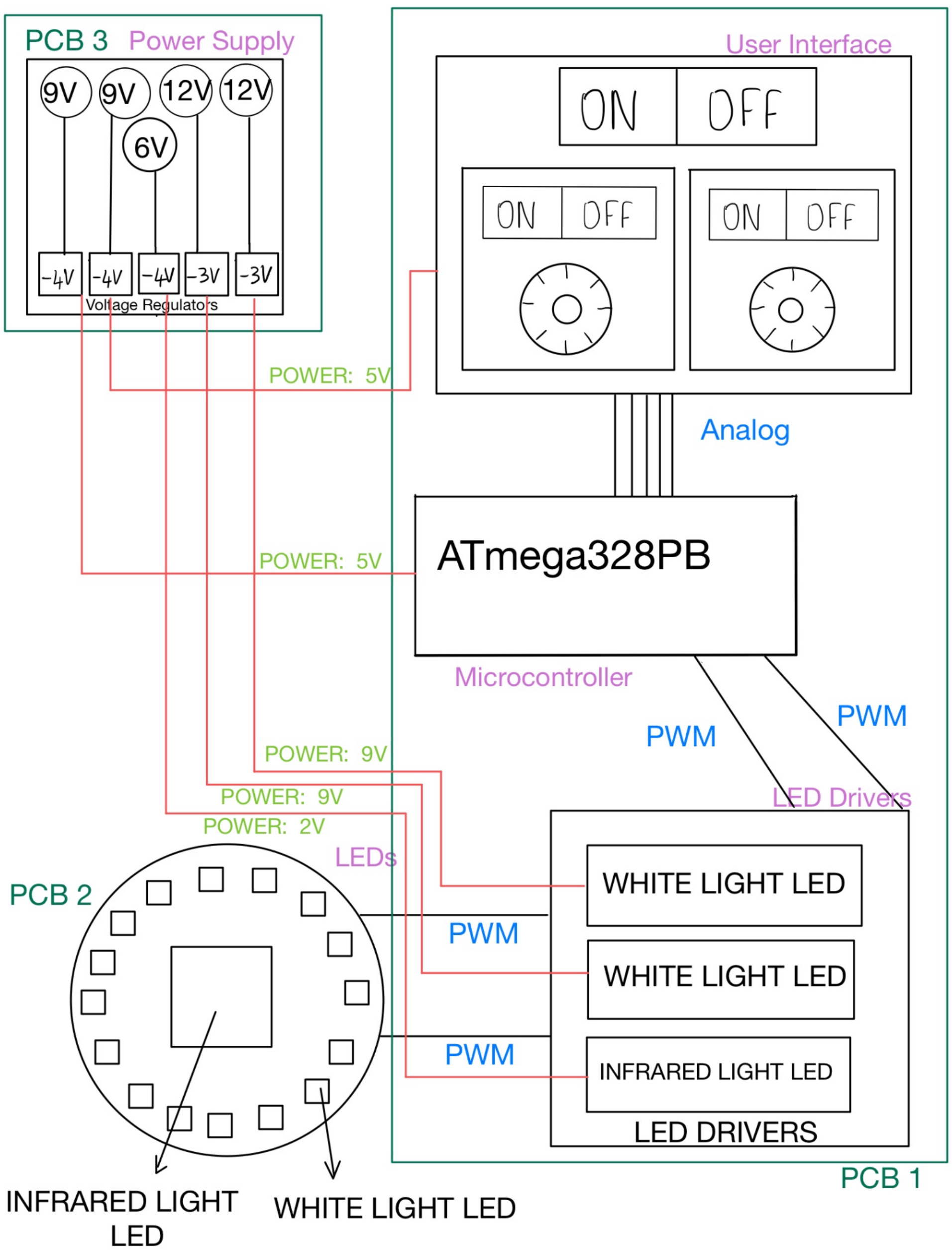


Figure 2. Block Diagram

Our surgical LED lamp would consist of two PCB boards(Table 1). The first board would house the supporting ICs and other electrical components like resistors, inductors, capacitors etc. The second board which would be a 6'' diameter Metal Core board which would specifically be for hosting the LEDs and dissipating the heat emitted from them faster. Since we will be placing all the LEDs on the same board, we need to ensure that there is (i) enough space for the LEDs as well as the power connections to the LEDs and ensure that the LEDs are placed as far apart as possible while still maximizing the number of LEDs to ensure that the heat dissipated do not negatively affect the neighboring LEDs or connections (ii) have a heat dissipation sink in place to keep the temperature of the board as low as possible.

2. Subsystem Descriptions

Power Supply

To provide power to all of the other subsystems, we will use three 18650 rechargeable batteries. The required power that each system will need is different, and we decided to have a setup of one power supply with multiple buck converters to control the amount of voltage that will be passed to each subsystem. The microcontroller needs 5 volts, the user interface needs 3.3 volts, the infrared red LED needs 5 volts, and the white LEDs need 9 volts. The white LEDS needs 9 volts since we decided to split the 24 LEDs into two groups 12. From the 12 LEDs, we would have three groups of 4 LEDs where the 4 LEDs are parallel. Since one 18650 rechargeable battery provides 3.7 volts, we needed 3 of the 18650 batteries, which will provide 11.1 volts to supply all subsystems. In terms of current, the batteries offer 9900 mah, which would be enough to supply the rest of the subsystems. One big reason we chose to use the 18650 batteries is because these batteries are rechargeable. Having the batteries rechargeable reduces the waste of needing to replace batteries each time the batteries die, which would be fast considering the number of LEDs we have to light up. We could have used a power cord, but it would not be ideal to always be near a wall, so we opted for these 18650 batteries instead. Since we are using rechargeable batteries, we designed our recharge circuit on a separate PCB where the batteries would be recharged from a DC power.

Voltage Regulators

The voltage regulator will be used to provide stability and control the voltage that will be supplied to the other subsystems. We will be using buck converters, and we will use one different regulator for each subsystem. The first buck converter is for the microcontroller, and it will be a TPS560200 with a layout of resistors and capacitors (see the supporting materials for TPS560200). The amount of voltage that is outputted will depend on the two resistors that are connected to Vout. To achieve 5 Vs, the resistor values are 105K Ohms and 20 K Ohms. The next buck converter is for the User Interface, where we use another TPS560200 with the same resistor and capacitor layout (see the supporting materials for TPS560200). Like the previous buck converter, two resistors that are connected to Vout will determine the output voltage. To achieve 3.3 Vs, the resistor values are 61.9K Ohms and 20k Ohms. The third buck converter will be used for the white LEDs. The buck converter we will use for this is the PTPS7B8601QDDARQ1 with a different layout of resistor and capacitor (see the supporting materials for PTPS7B8601QDDARQ1). The resistors that are connected to Vout will determine the output voltage. To achieve 9 Vs, the resistor values are 0.1 Ohms and 1.3 Ohms as the resistors combined have to be with 0.1 ohms and 2 ohms. The last buck converter used for the infrared LED is another TPS560200. Since we need 5V, the setup will be the same as the microcontroller, as that setup will output 5Vs.

User Interface

The interface that will allow the user to work with this design consists of five major components. The user interface block will send information to the microcontroller regarding which LEDs to turn on. Specifically, the interface will contain three toggle switches - one to turn on the entire LED subsystem, one to turn on the infrared LED and one to turn on the visible light LED. The specific toggle switch that we will be using is the A11JP from NKK Manufacturers. This toggle switch was chosen because it SPST(single pole single throw) and the switch has a minimum voltage requirement of 20mV and a maximum of 28V; the applicable range for the current is 0.1mA ~ 0.1A. This will allow us to have a good range of voltages to supply to our three switches. These three switches will be a toggle switch that is actuated by moving a lever back and forth to turn the LED system on and off. The on position for the toggle will be up and the down position will be off. Along with these signals, two potentiometers will be used for control over the brightness of the infrared and visible lights. The potentiometers will be 100 ohms and will have a rated voltage of 120V. The potentiometer will be connected to a resistor to determine the voltage across. The three switches and the two potentiometers will be sent as signals to the microcontroller in order to allow the microcontroller to determine which LEDs should be turned on. The switches will signal a 0 or 1 to pass in the information about which switches are turned on. These signals will be sent to the microcontroller using SPI communication because compared to I2C, it is a faster communication protocol which will be more beneficial to the user as it is important to be able to turn the switches on and off, as well as change the brightness of the lights.

Microcontroller

To communicate the changes in the user interface to the LEDs, we will be using the

ATmega328PB microcontroller. This microcontroller is low-power at around 5V which would be good for our group that wants our project to be as small as possible. The microcontroller will take in input from the user interface using the I/O pins where the values passed will determine the state that the LEDs should be in. Then, using the SPI, it will signal to the correct set of LEDs in order to turn on the system of LEDs. Once the switches are turned on, the potentiometers for each LED system will be able to send information to the microcontroller which will take in the voltage of the potentiometer and the LED drivers will make sure that the brightness of the LED system is consistent with the potentiometer. The ATmega328PB microcontroller has two Master/Slave SPI Serial Interfaces which will be used in communication between the UI and the microcontroller. Using the signals for the switches, there will be logic to determine which set of LEDs should be turned on.

LED Drivers

To regulate the current to the LEDs, we have decided to use LED drivers which would output the appropriate level of current for various levels of brightness. Our primary criteria for choosing a LED driver was to ensure that the circuit was as efficient as possible as LED circuits can be highly lossy if not carefully designed and therefore the LED drivers need to be high efficiency switching LED drivers. We chose the TPS92205x 65-V 2-A / 4-A Buck LED Driver with Inductive Fast Dimming since it meets our requirements of handling relatively higher current and voltage levels while ensuring that the power consumed is as low as possible[1]. The user interface knobs and switches would communicate with the microcontroller which in turn would interface with the LED drivers and appropriately send PWM signals of varying duty ratios to the LED driver. The duty ratio can vary from 1% to 100% and a higher duty ratio would produce a brighter LED setting[1]. We would have a fault signal that is sent from the drivers to the microcontroller that would pull high in the event of a fault like overvoltage etc. Since we have two types of LEDs (infrared and white light LEDs), we need to have at least two LED drivers to drive them separately as we want to individually want to control the brightness of the two types of LEDs[2]. Since we are using 24 white light LEDs, we want to divide them in two batches to have an LED driver each for two reasons: (i)increase reliability and robustness as even if one batch of LEDs fail, the other would still be able to work, (ii)decrease the power supplied to each LED driver which inturn would reduce the size of some of the components like the inductors and capacitors. The voltage to the LED driver and in turn the LEDs would be from the power supply and voltage regulators as additional protection method[2].

LEDs

We will be using two kinds of LEDs for this project. Common to both these LEDs is that they should be able to withstand high temperatures as there will also be heat emitted 1. Infrared

LEDs: We will have one infrared LED in the middle of our LED PCB. This will be invisible to the human eye as it operates in the 780nm wavelength range[7]. We will be using an 1-Watt infrared LED and our consideration behind choosing this is that it can provide reasonable luminance while at the same time having the power requirements low enough to be powered from a smaller power supply and not produce excessive heat that would negatively affect the other white light LEDs on the same board. We chose the Lumixtar SMD3030 1W IR 780nm High Power LED since it fit these criteria. It takes a nominal current of 350mA and a forward voltage drop of 2.8V. This LED interacts with its LED driver which controls its brightness based on different average current voltages. 2. White Light LEDs: Surrounding the infrared LED are the white light LEDs. We decided to get 24 white LEDs on our board. We had a lot more choice when it came to choosing a manufacturer for this. We chose a standard Luminus MP-2016-1100-27-90 warm-white light LED for this. It has a forward voltage drop of 3V and a nominal current of 60mA, therefore it is rated for 0.18W power. Since there are a lot more of these LEDs, we decided to choose individual LED power to be less than the infrared 1W power rating.

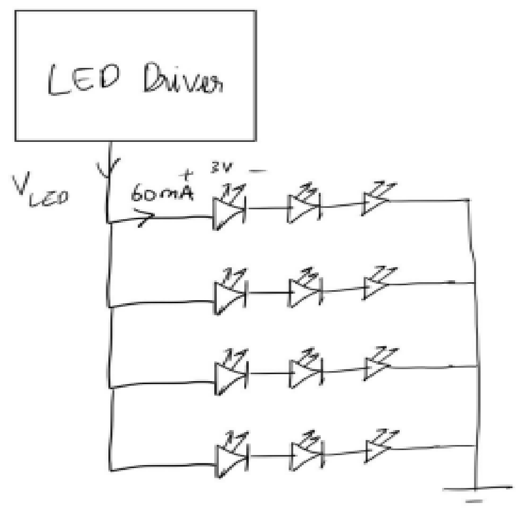


Figure 3. Schematic for one batch of white light LED

3. Subsystem Requirements and Verifications

SUBSYSTEM	REQUIREMENTS	VERIFICATION
Power Supply	1. The power supply for the	1a. We can check using a

	microcontroller should be able to continuously supply 5V +/-0.3 V. This is to ensure that the PWM has enough voltage to drive the LEDs. With the use of a buck converter (TPS560200 4.5-V to 17-V Input, 500-mA Synchronous Step-Down Converter With AdvancedEco-ModeTM), the voltage should be lower from the main power supply to 5V.	voltmeter that there is only 5V getting sent to the microcontroller. 1b. The microcontroller is able to function as intended which would mean that there is sufficient power getting supplied to the microcontroller.
	2. The power supply for the user interface should continuously supply 3.3 volts. We will use a buck converter (TPS560200 4.5-V to 17-V Input, 500-mA Synchronous Step-Down Converter With AdvancedEco-ModeTM) to lower the voltage from the main power supply to 3.3 V.	2a. We can check using a voltmeter that there is only 3.3 V getting sent to the User Interface. 2b. The User interface is able to function control the LED lights assuming that the microcontroller is correct which means that the power supply to the user interface is sufficient.
	3. The power supply will continuously provide the white LEDs groups with 9 volts and 240 mA. There will be a buck converter (PTPS7B8601QDDARQ1 500-mA, 40-V, Low-Dropout Regulator With Power-Good) to lower the voltage from the main power supply 9V.	3a.We can check using a voltmeter that there is only 9V getting sent to the white LEDs. 3b. All of the white LEDS should be turned on when the User Interface turns all of the LEDs on as that means enough power is supplied to all of the LEDs. If only a few are turned on, then the power

		supply is incorrect or the converter.
Voltage Regulators	1. The buck converter (TPS560200 4.5-V to 17-V Input, 500-mA Synchronous Step-Down Converter With AdvancedEco-ModeTM) will be used to regulate the 5V from the power supply to the microcontroller.	1. We will use a voltmeter to measure the output of the buck converter and the resistor and capacitor layout. In order to pass, the value measure has to be 5V as the microcontroller needs 5V to operate.
	2. The buck converter (TPS560200 4.5-V to 17-V Input, 500-mA Synchronous Step-Down Converter With AdvancedEco-ModeTM) will be used to regulate the 3.3V from the power supply to the User Interface.	2.We will use a voltmeter to measure the output of the buck converter and the resistor and capacitor layout. In order to pass, the value measure has to be 3.3V as the user interface needs 3.3V to operate.
	3. The buck converter (PTPS7B8601QDDARQ1 500-mA, 40-V, Low-Dropout Regulator With Power-Good) will be used to regulate 9V to the two group of white LEDs from the power supply.	3a. We will use a voltmeter to ensure that 9V is getting output from the buck converter and the resistor and capacitor circuit. To pass, 9V needs to be outputted, or not all white LEDs will have enough power to light up. 3b. Using the Ammeter, at least 240 mA is outputted, as 240 mA is the minimum for all white LEDs in a group to turn on.
		4a. We will use a voltmeter to

	4. The buck converter (TPS560200 4.5-V to 17-V Input, 500-mA Synchronous Step-Down Converter With AdvancedEco-ModeTM) will be used to regulate the 5V from the power supply to the infrared LED.	ensure that 5V is getting output from the buck converter and the resistor and capacitor circuit. To pass, 5V needs to be outputted, or the infrared LED won't turn on. 4b. Using the Ammeter, at least 350 mA is outputted, as 350 mA is the minimum for the infrared LED to turn on.
User Interface	1. The interface should allow user to turn on entire LED system with the main switch	1. The voltage that is being supplied to the switches can be tested to see if the on/off functionality of the switch is correctly changing the voltage. We will be supplying the switches with 5V so the switches will be using a voltmeter to check that the voltage being supplied becomes 0. (Applicable Range for the current will need to be 0.1mA ~ 0.1A at a minimum of 20mV ~ a max of 28V)
	2. Each of the LED systems, infrared and visible, will have a switch to turn on that specific LED system	2. Same as above. The voltage will be checked across resistors for the two LED switches to make sure that the correct voltage is flowing through when the switch for an LED is turned on/off.
	3. The three toggle switches that will turn on the LED system need to	3. Check the voltage across resistor when switch turned

	be within the max and min voltage ratings so that the LEDs turn on and off when the switch sends the min/max voltage to the microcontroller and LED drivers	off to see the maximum voltage and when the switch is on to see the minimum req so that it is within the bounds of the toggle switches voltage rating.
	4. Once the switches are turned on, the potentiometer can be used to change the brightness of the specific LED.	4. The potentiometer can be tested by having someone adjust the potentiometer while checking the ends of the potentiometer to see if the resistance is being adjusted. The potentiometer is 100 ohms so we will make sure that the range of the resistance will be able to reach that by checking the voltage of the resistors with a voltmeter.
	5. Each of the five components have information that will be sent to the microcontroller through signals that will allow the microcontroller to determine which set of LEDs to turn on/off. This will need to be communicated to the microcontroller using analog and I/O input to the microcontroller.	5. We can use a voltmeter to test the voltage that is being sent to the microcontroller at the analog or I/O pin to make sure that the communication protocol is correctly passing information from the switches and the potentiometers.
Microcontroller	1. The microcontroller should firstly be able to read the potentiometer voltages accurately and if the switches are on or off.	1. We will be checking firstly to see if the signals from the user interface are being sent and correctly interpreted by the microcontroller. We can do this using turning the switches on and off and checking the voltage across

		the resistors and the resistance for the potentiometer and checking the voltage at the analog and I/O pins to make sure that the values are consistent.
	2. It should be able to produce accurate duty ratio PWM signals to the LED drivers for the two types of LED drivers. The duty ratio is proportional to the voltage across the potentiometer or completely pulled to low if the respective switch or the master switch is turned off. The 5V is around the nominal voltage expected across the potentiometer at its highest resistance setting. $\mathbf{DutyRatio_{PWM} = V_{potentiometer}/5V}$	2. The voltages from the potentiometer are going to be checked to by checking the brightness of the LEDs that are turned on. We will be checking the voltage across the LEDs to make sure that the correct duty ratio is set for a specific potentiometer resistance.
	3. It should have enough storage to contain our logic for controlling the LED drivers.	3. Make sure that the logic is able to be stored in the microcontroller and that the correct set of LED drivers are being turned on based on the five signals that are being sent from the microcontroller. This can be checked by making sure the infrared LEDs are correctly on when the switch for them is turned on and the white LEDs are on when the switch for white LEDs is

		turned on.
	4. In the event of a fault, it should be able to turn off the LED driver PWM signals to low.	4. Have edge cases - test with overvoltage conditions to make sure that the LED drivers are being turned off in the event of a fault signal from the LED drivers. 5. Check the duty ratio produced by the microcontroller going to the LED driver interface. The 5V is around the nominal voltage expected across the potentiometer at its highest resistance setting. $\mathbf{DutyRatio_{PWM} = V_{potentiometer}/5V}$
LED Drivers	1. The LED driver most importantly should be able to achieve the desired switching frequency. We chose the 400kHz since it is high enough that the human eye cannot detect the flickering on and off the LEDs. This is achievable since the LED driver can support 100 kHz to 2.2 MHz. We can tolerate a relatively large tolerance on this since the human eye cannot reasonably notice a flicker when the frequency is over 200 Hertz.The frequency of the current output is at 400kHz with a higher tolerance of +/-10%.	1. We can verify this by measuring the output current waveform to LEDs using a current probe and an oscilloscope and then both manually and through the oscilloscope ensure that the current waveform has the required frequency of 400kHz.

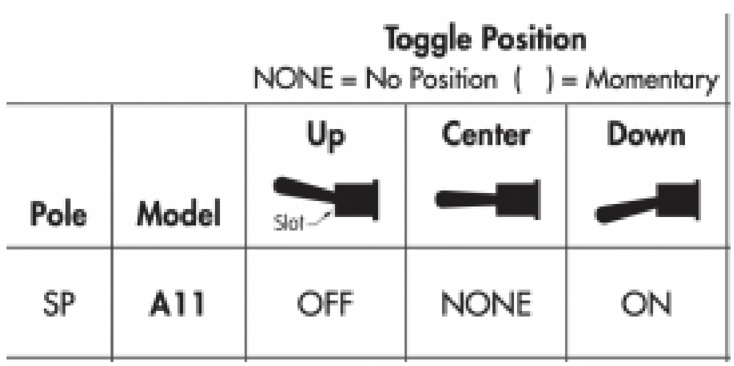
	2. Another important aspect of the LED driver is that it should be able to produce the duty ratio of the current waveform as requested by the microcontroller. When the LEDs are to be turned ON, the duty ratio can range from 1% to 100% of the period of the current waveform. The lowest that the PWM on time can go to is 150ns which is much lower than the 1% dimming at our switching frequency 400kHz so this will not be a constraint when designing our project. The duty cycle of the output current is the same duty ratio with a tolerance of +/- 1% as the input PWM signal from the microcontroller.	1. We can verify this by measuring the PWM signal generated by the microcontroller to the LED driver and then also measuring the PWM current signal produced by the LED driver on an oscilloscope and voltage and current probes. Then we manually compare the duty ratios on both these waveforms to see if they are similar to each other.
	3. Finally the voltage and current supplied through the LED drivers should not exceed the maximum voltage and current ratings of the LEDs. a. For the infrared LED, the voltage supplied cannot be greater than 2V but lesser than 1.8V and the current supplied cannot be greater than 500mA. The LED driver has to ensure that these limits are not exceeded. b. For the white light LED, since each batch of 12 LEDs are arranged in series of 3 LEDs paralleled as four columns. Each white light LED can handle a maximum of 3V and a minimum of 2.9V and	Voltage supplied: Ensure that the voltage supplied to the LEDs are within the voltages the LEDs can handle. a. Infrared LED Driver: 1.8V to 2V b. White Light LED Driver: 2.9V to 3V Current Supplied: a. Infrared LED Driver: 350mA to 500mA b. White Light LED Driver: 60mA to 120mA 1. We can verify this by connecting voltage and current probes to the output signals to the LEDs and then connecting these probes to an

	maximum of 120mA and a nominal current of 60mA. So the minimum voltage the LED driver can supply is 9V and a maximum of 9.6V. The current maximum it should supply is 480mA.	oscilloscope where we can see if the voltage and current waveforms and within the tolerable values. 2. We will then do the above for different PWM width settings to ensure that the voltages and currents are still within limits. Some PWM width settings: 10%, 30%, 50%, 60 %, 70 %, 80%, 90%
LEDs	1. The LED should be bright enough on the highest setting on the brightness knob to luminate the cancer cells. a. For the infrared LED: The radiant power should be between 100-200mW and this can be measured using a photometer. b. For the white light LED: The expected flux is 16-18 Lumens each. We can use a light meter to measure the Lumens.	For both these LED testings, we need to use a lightmeter to measure the lumens from the LEDs. This is especially important for the infrared LED since we are unable to see it with a human eye. The visible light LED can be manually also verified to see if the brightness is changing as we change the PWM width.

	2. The wavelength of the LEDs should be within the desired limits and we can measure this using a spectrophotometer although this might be hard to obtain. a. For the infrared LED: The wavelength should be between 780nm and 785nm. b. For the white light LED: The wavelength should be between 400nm and 700nm.	We can verify the wavelength emitted by the LED by using a spectrophotometer although this will be a little difficult to obtain. The wavelength emitted by the white light LED can roughly be estimated to see if the color corresponds to a warm white light as rated or if it is a different color which would indicate a malfunction.

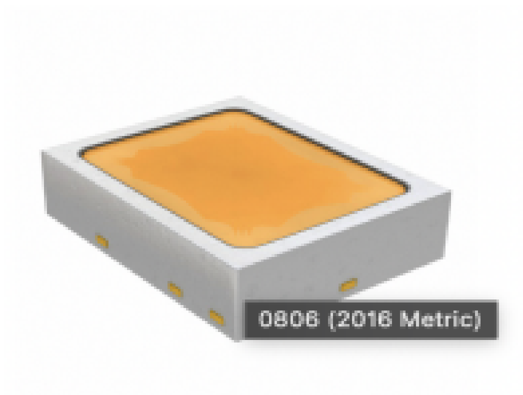
4. Supporting Material

- Toggle Switch:

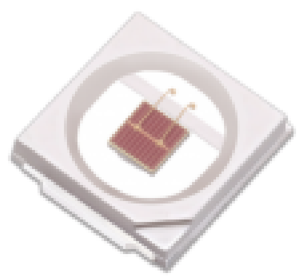


		Toggle Position NONE = No Position ( ) = Momentary		
Pole	Model	Up Slot	Center	Down
SP	A11	OFF	NONE	ON

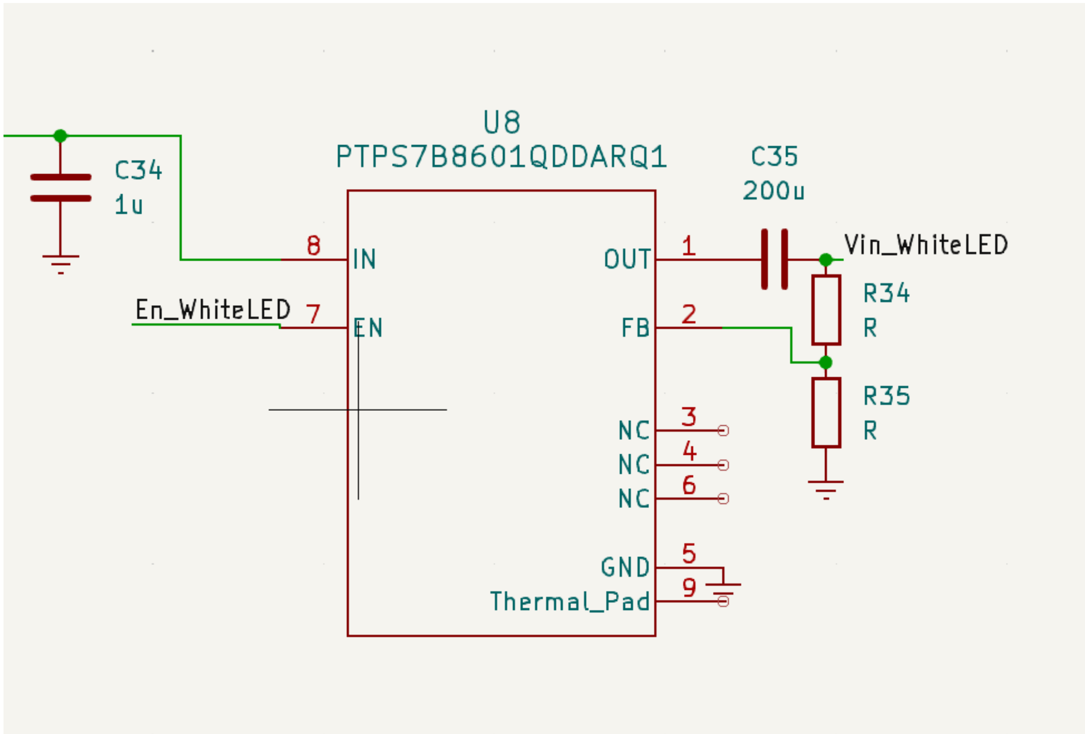
- White LED:



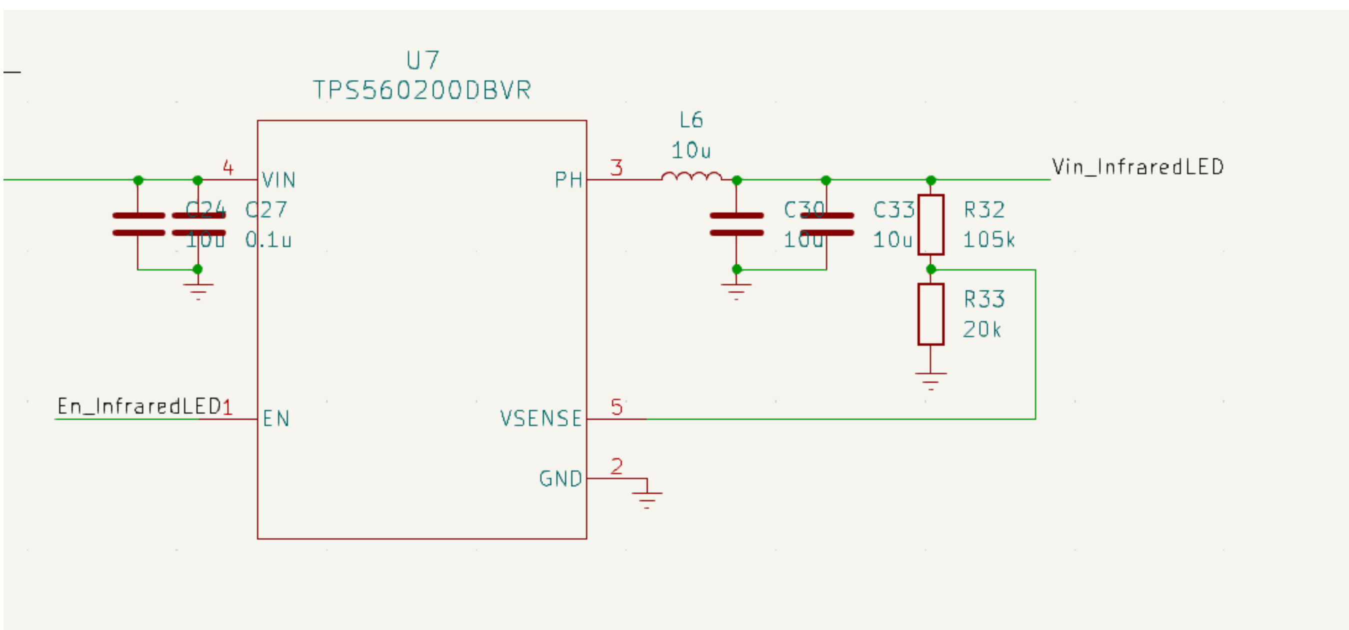
- Infrared LED:



- PTPS7B8601QDDARQ1



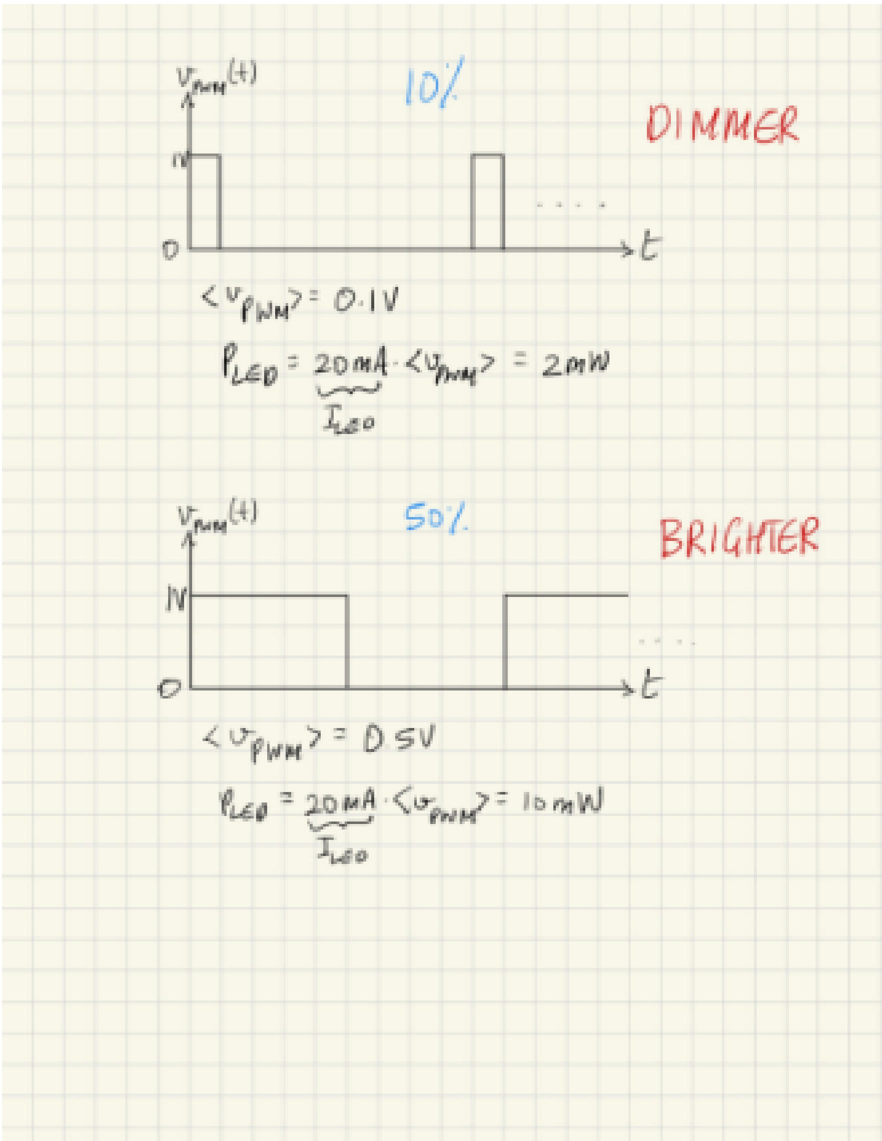
- TPS560200DBVR



5. Tolerance Analysis

Something that is highly critical to the success of our project is the ability to adjust the brightness of the LEDs. Since the output of the LEDs are interpreted by the human eyes, there is less emphasis and importance on the speed of the data being transmitted. So the transmission speed can be moderately fast. So this is not a design constraint. Ensuring accurate generation and transmission of the PWM signal from the microcontroller and from the LED derivers is more important to the working of the project.

An illustrative analysis of setting the different brightness of the signal can look like:
Assuming the LEDs take around 20mA current.



As seen above, this way the power to the LED can be adjusted and as along as the microcontroller can produce the PWM, the design will be successful. The microcontroller that we chose has two 8-bit timers with maximum count 65535 and one 16-bit timer with maximum count 65535 that can produce the PWM waveform. We can use the 16-bit timer to produce our PWM signal with the appropriate duty ratios to send to the LED drivers. It is essential that the LED drivers then use this duty ratio to send the appropriate current signals to the LEDs.

6. Cost

To put together the subsystems for this device, the following parts will need to be ordered using our budget:

- User Interface:
  - Three toggle switches - each one at $4.92: $14.76
  - Three potentiometer pack - $20
- LEDs:
  - Infrared Light:
    - Each at an estimated $10
  - White Light: LED XNOVA WARM WHITE 2700K 0806
    - Each one at $0.18: $4.32

- LED Drivers:
  - TPS92205x 65-V 2-A / 4-A Buck LED Driver
    - Each at $1: $3
- Batteries:
  - 3V pack of 12: $30
  - 9V pack of 2: $9
- Voltage Regulators:
  - $11
- PCB: $50
- Total: $152.08

Cost Labor:

The average salary for a computer engineer is around $93,782 per year so according to that estimate, an hourly salary for an individual working in the industry would be around $45.08. For our project, we will be putting in around 10 hours a week, so this will be $450 in a week for each of us. We will be working on this for 8 weeks, so each of our team member's cost of labor will be around $3600. While we mentioned 10 hours, we might be putting in more hours for the preparation of our demo and the research behind the project we are working on.

7. Schedule

Date	Manogna Jeremy Yoga
10/2	Look into the logic of the microcontroller on how to send the SPI signal to the LED to get them to work as we want Create a rough draft of the PCB design that will get shipped out next to to give an idea on what should be on the PCB Look in the PCB Design where the white and infrared LEDs will be connected to determine what will be needed on the PCB

10/9	Connect the user interface to the microcontroller on a dev board to test the SPI and start looking at edits for the round 2 of PCB design.	Debug and Test the PCB design in time before the first round of orders. Finish at least one day before.	Design and Test the PCB design for the LEDs. Finish this in time for the first round of orders.
10/16	Debug and Test the new PCB design in time before the second round of orders.	Test the PCB designs that were sent from the first round and look for the errors.	Design and Test the PCB design for the LEDs. Finish this in time for the second round of orders.

10/23	Test the second round of PCB design from order and test the connection from the microcontroller to the LEDs on dev board.	Debug and Test the last PCB design in time before the third round of orders.	Design and Test the PCB design for the LEDs before the last round of orders.
10/30	Test the finalized PCB Design to ensure everything we want is working as intended	Test the connections between the user interface to the LEDs on the dev board.	Test the finalized PCB LED Design to ensure the functionally and shape is what we

			wanted
11/6	Reserved for unexpected circumstances that arise from testing the final PCB design.	Put all of the parts together using the finalized PCB designs to ensure they work as intended.	Reserved for unexpected circumstances that arise from testing the final PCB design.
11/13	Reserved for last second changes that are arise during mock demo	Reserved for last second changes that are arise during mock demo	Reserved for last second changes that are arise during mock demo
11/20	Fall break	Fall break	Fall break
11/27	Prepare for the demo and	Prepare for the	Prepare for the

	demo and presentation. Start working on the report.	demo and presentation. Start working on the report.	demo and presentation. Start working on the report.
12/4	Present presentation and finish the report.	Present presentation and finish the report.	Present presentation and finish the report.

8. Ethics and Safety

Our project aims to create a controllable NIR and bright white LEDs that will help detect cancer cells. One thing that could be an issue is the safety of the LEDs. The first code in the IEEE Code of Ethics states “the safety, health, and welfare of the public.” Since we are trying to get the white LEDs as bright as possible, looking directly at the LED could damage our eyes during development and the users later. As a result, during development, we will be extra careful when handling the LED and unique eyewear when testing the brightness of the white LED. Not only that, the NIR LEDs can also damage the eyes since they emit longer wavelengths than visible light. If one were to look at the NIR LEDs for short periods directly, nothing would happen, but it would still require attention when handling them. This would also apply to the user when using the product. The caution when handling the LED direction would ensure no damage to the eyes would happen to the user. Since the IR light can harm the human eye, there are ethical issues that arise when this device is used maliciously with a intent to harm others.
In the event that we test our project on a cancer patient, we will follow Section II of the IEEE Code of Ethics[9].

We will need to make sure that all individuals are prepped with sufficient information about the effects of infrared light and bright light. They will also be made aware that bright light can often trigger traumatic experiences that the individual may have faced. The testee will also be made aware that the detection using this device does not guarantee the detection of all cancer cells. Furthermore, using this device will help in the detection of cancer cells, but it will not necessarily stop any misdiagnosis of cancer and the specific locations that cancer growth might be apparent. We will “treat all persons fairly and with respect, and to not engage in discrimination”, “to not engage in harassment of any kind” and “to avoid injuring others, their property, reputation, or employment by false or malicious actions.” As said before, we will abide by codes 7, 8, and 9 of the IEEE code of Ethics with everyone involved in the testing[9]. Also, we are using infrared LEDs, which are being bought by manufacturers. This will entail being close to hazardous environments and materials that could be dangerous while designing and creating. According to OSHA(Occupational Safety and Hazard Administration), workers need to wear protective, electrical personal equipment to ensure that they are safe and not being harmed[8].

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